

CBRN Escape Respirator

Breathing Gas Control

Concept Requirement:

- CO₂ – Maximum Average Inhaled
 - Concentration of 2.5% Max
 - 42 CFR, Part 84
- O₂ – Minimum Inhaled
 - Concentration of 19.5%
 - 42 CFR, Part 84

CBRN Escape Respirator

Breathing Gas Control

- Human Subject Testing
 - Greater than 80 kg, 2 subjects
 - Less than 60 kg, 2 subjects
- Work Rate:
 - Standing, 2.5 and 3.5 mph: treadmill
- Test for Duration of Each Respirator

CBRN Escape Respirator

Breathing Gas Control

- Benchmark Testing
 - Simulate Six Work Rates
 - Low Work Rate – 0.5 l/min VO_2
 - Work Rate – 1.0 l/min VO_2
 - Work Rate – 1.5 l/min VO_2
 - Work Rate – 2.0 l/min VO_2
 - Work Rate – 2.5 l/min VO_2
 - Work Rate 2.5 l/min VO_2
 - High Work Rate – 3.0 l/min VO_2

CBRN Escape Respirator

Breathing Gas Control

- Benchmark Testing (ABMS):
 - Commercially Available Escape Sets
 - Multiple ABMS Tests with Each Respirator
 - Carbon Dioxide Levels > 4% Common
 - Oxygen Concentrations < 19.5% Common
- Non Conclusive Results

CBRN Escape Respirator

Breathing Gas Control

- Benchmark Testing (Human Subject)
 - Testing 7 Test Subjects
 - 4 Males, 3 Females
 - Work Rates:
 - Standing
 - Treadmill @ 2.5 mph
 - Treadmill @ 3.5 mph

CBRN APR Escape Respirator

- Benchmark Testing- Human Subjects
 - CO₂ – 5.5% Maximum
 - O₂ – 14.8% Minimum
 - Both CO₂ and O₂ Exceed NIOSH Expected Limits
 - Physiological Consequences

AIR-RESPIRATOR ESCAPE HOOD HOOD RESPIRATOR INVESTIGATION

Time Frame (min)		Estimated VO ₂ (l/min)	Time Completed (min)	Incident	F _i CO ₂ min (%)	F _i CO ₂ ave (%)	F _i O ₂ max (%)	F _i O ₂ ave (%)	Time Completed (min)	Incident	F _i CO ₂ min (%)	F _i CO ₂ ave (%)	F _i O ₂ max (%)	F _i O ₂ ave (%)	Time Completed (min)	Incident	F _i CO ₂ min (%)	F _i CO ₂ ave (%)	F _i O ₂ max (%)	F _i O ₂ ave (%)
Man 1 98.9 kg	0-10	0.4 (stand)	10	none	0.7	2.7	20	18.2	7	Neck dam too tight - removed	0.6	none	20	none	10	Hyperventilated	2.6	3	20	18.6
	10-20	1.0 (2.5 mph)	10	none	1.2	3.3	20	17.2	10	Neck dam cut	0.7	2.7	20	17.5	10	Hyperventilated	2.2	4.4	20	17.5
	20-30	1.3 (3.5 mph)	10	none	0.9	3.5	20	17.5	10	Neck dam cut	0.4	2.7	20	17.5	10	Hyperventilated	2	3.9	20	17

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Man 2 115.2 kg	0-10	0.4 (stand)	10	none	0.6	2.6	20	18.1	10	Neck dam too tight - fogging	0.2	2.3	20	18	10	none	1.6	3.2	20	17.4
	10-20	1.2 (2.5 mph)	10	none	0.8	2.6	20	18	10	Neck dam too tight - fogging	0.3	1.8	20	18.3	10	none	1.6	3.1	19.5	17.2
	20-30	1.5 (3.5 mph)	10	none	1	2.7	20	17.6	10	Neck dam too tight - fogging	0.6	2.4	19.5	17.7	10	none	1.6	3.9	19.5	16.8

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Man 3 82.6 kg	0-10	0.3 (stand)	10	Fogging	1.4	2.7	20	18.5	10	Neck dam too tight - fogging	0.3	2.3	20	18.2	10	none	2.2	4.2	18	17.5
	10-20	0.8 (2.5 mph)	10	Fogging	1.4	3.3	20	18.5	10	Neck dam too tight - fogging	0.4	2.1	20	18.5	10	none	3	4.1	19	16.8
	20-30	1.1 (3.5 mph)	10	Fogging	1.2	3.3	20.5	18.7	10	Neck dam too tight - fogging	0.4	1.8	19.5	18	10	none	2.3	3.9	19.5	17.8

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Man 4 82.3 kg	0-10	0.3 (stand)	10	none	3.4	4.6	16.8	15.8	10	Neck dam too tight - fogging	0.5	2.2	19.5	18.1	1	Gagged on mouth piece- removed	2.6	none	18	none
	10-20	0.8 (2.5 mph)	10	none	2.8	5	17.9	15	10	Neck dam too tight - fogging	0.8	2.8	19.5	17.7	0	Not tested	none	none	none	none
	20-30	1.1 (3.5 mph)	10	none	3	5.2	17.8	15.7	10	Neck dam too tight - fogging	0.8	3.1	19	17.7	0	Not tested	none	none	none	none

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Wmn 1 60.0 kg	0-10	0.2 (stand)	10	none	2	3.5	19	17.8	10	Neck dam too tight; needed help donning	0.8	2.4	20.8	18.4	10	none	4.1	5.5	18.1	16
	10-20	0.6 (2.5 mph)	10	none	1.7	3.4	19.5	17.8	10	Neck dam too tight; needed help donning	0.7	2.4	20.1	18.8	10	none	2.8	4.7	19.5	16.5
	20-30	0.8 (3.5 mph)	10	none	1.2	3.3	20	18.3	10	Neck dam too tight; needed help donning	0.8	2.2	20	18.8	10	none	2.4	4	19.5	16.2

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Wmn 2 63.4 kg	0-10	0.2 (stand)	10	Fogging	2.1	3.6	18	16.2	10	Fogging; needed help donning	1.5	3.8	18.5	16.2	10	none	3.6	4.6	17.1	15.7
	10-20	0.6 (2.5 mph)	10	Fogging	1.8	3.9	18.3	16.3	10	Fogging; needed help donning	2.1	4.3	18	15.2	10	none	2.7	4.6	18.5	15.8
	20-30	0.8 (3.5 mph)	10	Fogging	1.2	3.3	19.3	16.8	10	Fogging; needed help donning	2	3.8	18.3	15.7	10	Headache	2.3	4.4	18.5	16

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Wmn 3 58.5 kg	0-10	0.2 (stand)	8	Neck dam cut; felt hot; "lightheaded"; peri-temporal pressure; removed	4.5	5.3	16.5	15	10	Neck dam cut; loose nosecup; fogging	0.4	2.2	19.5	17.8	2	"Could not breathe"; lightheaded; removed	4.4	5.2	16.4	14.8
	10-20	0.6 (2.5 mph)	4	Neck dam cut; felt hot; "lightheaded"; peri-temporal pressure; removed	4.4	5.5	18	16	10	Neck dam cut; loose nosecup; fogging	0.5	2.8	19.5	16.7	0	Not tested	none	none	none	none
	20-30	0.8 (3.5 mph)	0	not tested	none	none	none	none	10	Neck dam cut; loose nosecup; fogging	0.6	5.5	19.5	16	0	Not tested	none	none	none	none

CBRN Air Escape Respirator

- Benchmark Testing- Human Subject
 - Human Factors Issues Observed
 - Neck Seal Excessively Tight
 - Neck Constriction
 - Sensation of Strangulation
 - Mouth-Bit/ Gagging Reflex
 - Expel Mouth – Bit
 - Difficulties Donning Over Head
 - Insufficient Arm Strength to Stretch Over Head